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The influence of carbon monoxide and other gases upon plants*

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Some time since the authors began an investigation of the influence of carbon monoxide upon plants, in which this gas was used to replace partially or entirely the nitrogen of the air. Attention was directed chiefly to the effects upon the cell-contents, upon growth and developmental phenomena and no consideration was given to the possibility of the use or absorption of the substance by the plant. Later comparative series of experiments were made with nitrous oxide and various mixtures furnished for illuminating purposes.

The striking character of the results already obtained, as well as the recent publication by Bottomley and Jackson of their conclusions as to the ability of the green plant to utilize carbon monoxide in the construction of food-material (Proc. Roy. Soc. **72**: 130. 31 Jl 1903), led the authors to make public at this time some of the important facts that have been brought to light in their work.

In most of these experiments the CO used was prepared by the decomposition of oxalic acid with strong sulphuric acid. As a check, however, some additional series have been tried with the gas prepared from other sources, namely, potassic ferro-cyanide, which when treated with concentrated sulphuric yields CO as the only gaseous product, and by passing a current of carbon dioxide over glowing charcoal, giving pure CO. Although in all cases

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the chemicals used were of the purest form obtainable, it was not thought advisable to trust to the product being free from impurities. Of course in preparing CO from oxalic acid it was necessary to wash out the CO_2, which may easily be done, but in addition to this in all but the preliminary experiments the gas was passed over potassium permanganate, mercuric chloride, etc. The analyses of gases produced by both methods showed the presence of no impurity except a small portion of atmospheric air, which varied from 1.3 per cent. to 9 per cent. according to the method of preparation and the setting up of the experiment. The illuminating gas used was taken directly from the mains at Barnard College and at the New York Botanical Garden. No thorough analysis of this mixture was made, but the tests applied showed the presence of an amount of carbon monoxide not far from 40 per cent. of the total volume.

A small number of tests were made upon germinating seedlings and it was found that a proportion of 90 per cent. or higher of carbon monoxide in the air around the seeds prevented all action of swollen seeds except in the pea, which succeeded in making roots less than a centimeter in length, and ultimately killed all the seeds. A smaller proportion of the illuminating gas mixture was found to be inhibitory and fatal. Swollen seedlings of several species germinated in atmospheres containing about 70 per cent. of carbon monoxide, but the consequent growth and development was restricted.

The results obtained from the exposure of seedlings germinated in the usual manner gave many facts of great interest and significance. The seeds were placed in moist sphagnum and allowed to remain until the seedlings began to free themselves from the seed-coats, in short until the seedling reached a period of rapid growth when there would be likelihood of quick reactions to abnormal conditions. Glass vessels, varying in size according to the size of the seedlings, were then taken and after the flower-pots had been properly arranged in them, the air was completely replaced with water, after which a mixture of the gases desired was run in to displace the water, except for a water seal at the bottom. In the water some potash was placed, to absorb the CO_2 given off, great care being taken to have the flower-pot containing the seedlings

so supported that there would be no danger of the potash "crawling" and reaching the young plants. The diminution in volume caused by the absorption of CO_2 was corrected by running in pure oxygen at intervals as required — usually twice every twenty-four hours. Thus the atmosphere (as repeated analyses showed) was kept at normal oxygen pressure and the CO, being so very slightly soluble in water, did not diminish perceptibly. The same is also true of the illuminating gas experiments. In all respects, even to the mechanical manipulation, the controls were treated in the same way as the experiments with the gases. All of the plants had equal illumination, and while of course in the winter time some etiolation is unavoidable, the conditions of the bell-jars were precisely similar in any one experiment.

A list of the seedlings on which experiments have been completed, up to date, is as follows: *Vicia faba*, *Zea Mays*, *Sinapis alba*, *Helianthus annuus*, *Triticum vulgare*, *Fagopyrum Fagopyrum* and *Oryza sativa*.

The effect of these gases on the condition and growth of the above-named seedlings may be considered under the following heads: (1) Growth in length; (2) growth of secondary members; (3) growth in thickness (primary); (4) growth curvatures; (5) formation of chlorophyl. It is to be understood that in all of the experiments of this series the nitrogen of the air was replaced with either CO or illuminating gas (referred to hereafter merely as "gas").

Under the first head we may take up for consideration a considerable number of measurements which have been made. These measurements are of the length of the primary root and of the shoot, or in the case of the monocotyledonous forms of the distance from the seed to the tip of the longest leaf. There is shown in general to be a very clearly marked retardation, which must finally amount to a toxic effect, in both CO and gas. Taking the average of three experiments with *Vicia*, each experiment being in itself an average of from 8–10 individuals, we find the approximate ratio of the length of the shoot about as follows: The normal being 25, in CO it is 15, and in gas only 10; while a similar comparison of the length of the primary root gives the following ratio: control 30, in CO 12, in gas 10. Corn seedlings

showed like discrepancies between the normal and the plants grown in CO and gas atmospheres. The ratios of the length of the seedling from the seed to the tip of the longest leaves, taken from three experiments each of which were the averages of at least 8 individuals, is: control 21, in CO 11, in gas 10; of the actual main axis itself: control 20, in CO 15, in gas 10; and of the primary root: control 40, in CO 15, in gas 10. The controls showed about twice as many unfolded leaves as did the plants grown in CO, while in gas the leaves had barely begun to break through their sheaths.

Buckwheat, sunflower and mustard seedlings exhibited similar behavior and the ratios of the length of their hypocotyledonary stems and of their primary roots would be nearly the same as the forms given above. Squash seedlings showed especially well-marked differences in the different gases, the caulicles of the controls being seven times longer than those in gas, while the roots of the former were ten times longer. Those in CO, though a little more developed than the ones in gas, were dwarfed as compared with the normal. Naturally the squash is sensitive to diminished light so that some etiolation was to be expected, but all were under equal light conditions. Perhaps the most striking of all the experiments were those with wheat and rice. The wheat grew but little in gas, but fared better in CO. As to the length of the shoot to the tip of the longest leaf, we have the following ratios: control 12, in CO 9, in gas 1; while on comparison of the average length of the several adventitious roots the difference is not so marked: control 2, in CO 1.2, in gas 1. The difference in the roots became evident on examining the branches; secondary rootlets were almost absent in the specimens from the gas, and were few in those plants grown in CO, but were not only plentifully developed but also branched again in the control experiment. The normal also showed two unfolded leaves with a third just unrolling, while in the CO specimens there was barely one, and in those from gas the leaves had hardly broken out of the curiously swollen leaf-sheath. Rice exhibited one of the most prettily graded series. It grew luxuriantly in the moist atmosphere, and the length of the leaf-tip from the seed being 1 in the gas culture, that in CO would be about 2 and the control 6, with a nearly similar ratio as regards

the average length of the several roots. As to the branching of the roots and the unrolling of the leaves, what was said about the wheat applies here.

In considering the secondary members both of the root and of the shoot, it may be said in general that the seedlings in gas and CO presented a very imperfect development. Branches of the shoot were only observed in *Vicia* and while the control showed such branches frequently the others did not. Secondary roots were observed in all cases, however, and it was found that in CO and gas the formation of the regular root-system was greatly retarded if not inhibited. In the latter secondary branches were few and poorly developed, while the controls would have a healthily developed system. In gas especially the roots often appeared sickly, more so indeed than the shoots. In the corn, while the normal root-system was far from being completely formed in CO or in gas, an interesting exception was seen as to the production of lateral members, which as has been said are usually fewer in these cases than in the normal. Below the circle of adventitious roots ordinarily developed in corn seedlings a considerable number of supernumerary secondary roots arose without order and grew out for a millimeter or two.

In connection with this may be introduced a description of the peculiar thickening noticed at the base of the stem of many of the seedlings grown in CO or in gas. In *Vicia* for instance the normal diameter of the base of the stem next the seed being 3.5 mm., the CO specimens were 4.5 mm., and those in gas were 5.0 mm. in diameter. *Helianthus*, *Fagopyrum* and *Sinapis* also showed a similar but less well-marked thickening, and the curious enlargement of the leaf-sheath in the wheat and rice seedlings has already been referred to. In corn, however, the difference in size of the stem-base is most conspicuous and seems to be connected with the formation of the supernumerary roots just spoken of. The corn is the only form that has so far been examined microscopically and the anatomical conditions are briefly as follows. The cells of the cortical parenchyma are greatly enlarged, though apparently no more in number. In the plants grown in CO these cells measure from one third to one half more in diameter than do those of the control, while in the gas speci-

mens they are swollen to nearly twice their ordinary diameter. The bundle-ring of the developing plerome cylinder is scarcely greater in diameter in the CO specimens than it is in the normal and in the sections examined shows little or no difference in structure. Not so, however, in the plants from the gas cultures. Here the axial bundle-strand is nearly twice the normal diameter, the size of all of the developing bundle-elements is exaggerated to about the same extent as is the parenchyma, and the walls are much less thickened than they normally are. The difference is very striking. The whole stem-base appears to be in a less differentiated condition than normal to it at that age, a circumstance which perhaps accounts for the very free formation of the extra roots.

The normal growth being in general checked by the gases used, it is natural to suppose that the growth-curvatures would also be affected, and such appears to be the case. In CO the seedlings most sensitive (*e. g.*, mustard) showed little or no curvature in response to phototropic stimulus, and in gas whatever development took place was quite irrespective of the angle of the incident rays. Similarly there seemed to be a less degree of sensibility to geotropic stimulus, especially noticeable in the adventitious roots of the corn and in those supernumerary roots formed in the thickened stem of the same plant.

Together with the other inhibitive effects of CO and gas it was noticed that the chlorophyl formed much less quickly than under normal conditions. In fact mustard seedlings, sprouted in the dark, scarcely greened after a week's exposure to sunlight while in an atmosphere with gas, though the control showed the effects of the light in the course of a few hours. In CO the action was also retarded, but not nearly so much as in gas. It must not be supposed, however, that this lack of chlorophyl is necessarily the explanation of the retarded growth. Most of the seedlings in the above described experiments did not in the course of the experiment pass beyond the stage where they chiefly rely upon the stored food in the seed. Also in some cases the chlorophyl did finally assume its normal color, without bringing about any increase in the rate of growth. Finally it may be said that some experiments which were kept in the dark all the time, showed that the etiolated plants behave similarly to the ones in the light.

Effect of nitrous oxide. — N_2O was prepared from NH_4NO_3, and purified over ferrous sulphate, potassic hydrate and water. Seedlings of mustard were arranged in the bell-jars in the same manner as in the CO experiments, except that a mercury seal was used. At the beginning of the experiment the hypocotyledonary stems of the seedlings were on the average 4 mm. long. After five days those of the control were 5 cm. and of the ones in 80 per cent. N_2O, 2.6 cm., while the average of those in 40 per cent. N_2O was about half-way between the two. The root-system also showed the effect of the gas, being both shorter and less branched in the seedlings exposed to the N_2O.

A trial experiment was also made with fungi to see if these plants could use the gas as a source of nitrogen. Three parallel series were set up, one with a normal culture fluid containing a nitrate and two with the same culture fluid minus the nitrate. Of the last two, one was left in air, the other exposed to an atmosphere containing about 60 per cent. N_2O, and normal oxygen. Up to this time neither of the series without nitrates have shown any development, while the control with the normal culture solution has produced a thick fruiting felt. The fungi used were *Sterigmatocystis nigra*, *Penicillium glaucum* and *Rhizopus nigricans*. It has, indeed, been reported somewhat indecisively that nitrous oxide can serve as a nitrogen source, but these negative experiments do not agree with such a conclusion.

Another phase of the influence of the gases was to be found in their action upon the shoots and roots of woody or succulent perennials. If the basal portion of a shoot of such plants as *Gossypium* or *Haematoxylon* were enclosed in a bell-jar with the stem extruding through a tubulure properly sealed around it, both illuminating gas and carbon monoxide acted as a very slow poison which caused the leaves to become desiccated and to fall off after periods varying from about four to twenty days, and the plants were killed.

If entire plants of *Haematoxylon*, *Mimosa*, *Meibomia* (*Desmodium*), *Opuntia* or *Mesembryanthemum*, were enclosed in the bell-jar containing the gases, several important reactions might be noted. First it was to be seen that if the enclosing chambers were filled with a mixture of carbon monoxide or illuminating gas containing over

90 per cent. of carbon monoxide, practical asphyxiation occurred in *Meibomia*, *Haematoxylon* and *Mimosa*, the leaves becoming discolored and turning brown, but not being cast away, the small amount of oxygen present and the strong toxic action of the other gases coöperating to kill the leaf before separatory layers could be formed.

In all tests in which a supply of oxygen fairly equal to the normal was present, the leaves of the three plants were discolored and cast away within a week, and at the end of that period appeared to be much more seriously damaged than those in higher percentages, which appearance however might be seen to be erroneous on closer examination. Plants exposed to both higher and lower proportions for two weeks revived and sent out new leaves when placed in the propagating houses. Tests with young plants of *Opuntia tuna* and with cuttings of a species of *Mesembryanthemum* showed that the last named is much more readily killed by the gases, the entire plant perishing after exposures for a month to atmospheres containing as much as 25.5 per cent. carbon monoxde.

In marked contrast with the foregoing is the behavior of the gametophytes of some of the mosses. Such forms as *Catherinea angustata*, *Dicranella heterophylla* and *Physcomitrium turbinatum*, were able to endure atmospheres containing the highest practicable proportions of carbon monoxide or of illuminating gas for periods of over three months, with but little damage and that to the older leaves, in which the cell-contents and chloroplasts were variously and deleteriously affected. In two instances sporophytes were formed. During this period the gametophytes had formed numbers of new leaves, and their resistance could not be attributed to the possibility of being in a resting condition.

Some observations on a more delicate moss, presumably *Mnium undulatum*, show that these gases are not always without effect even on these plants. It should be said, however, that the changes in the cell-contents herein noted proceed so far and no farther, without involving the death of the plant as a whole.

The *Mnium* leaves after exposure for about three weeks to atmospheres of 80 per cent. CO and of 80 per cent. gas respectively, were in general lighter in color. Microscopical examination con-

firmed this and revealed the fact that the chloroplasts had been considerably affected. In the control the cells were full of large, somewhat elliptical chloroplasts and about 2 per cent. of the cells appeared to be dead. In CO the chloroplasts were smaller, with considerable spaces between them, and were fewer in number. In shape they were usually similar to the normal, though in some cases they were curiously elongated. About 20 per cent. of the cells seemed to be dead. In gas as many as 33 per cent. of the cells were dead and often quite empty, and the chloroplasts were much fewer, paler and smaller than in the control, being often nearly spherical in shape. Some of the specimens were returned to the respective gases in which they had been, some were returned to the air. After two weeks the specimens returned to the air were examined. The cells not actually killed, had in both the CO and the gas specimens almost regained their normal appearance, though still somewhat paler than the normal. In the gas specimen, however, so many of the cells had been killed that the older leaves dried up. The growing tips of all appeared fairly healthy. The plants returned to the gases were examined after an additional five week's interval and very little difference was seen as compared with the condition presented at the first examination.

Philotria Canadensis (*Elodea Canadensis*) was exposed to the same conditions, being arranged so that it came in contact with the moist surrounding atmosphere. The leaves showed a somewhat similar degeneration, but rather more serious. After eight days exposure an examination of the CO experiment demonstrated that while the young leaves were not so much affected as compared with the normal, the older leaves were. Many cells in the latter had their contents plasmolyzed or completely disorganized. In the specimens from the gas more than half of the cells were dead and in those that were not the chloroplasts were small and pale. The occurrence of large oxalate crystals was common, suggesting a derangement of the assimilatory functions. In the control almost all of the cells appeared healthy and showed rotation.

Some specimens of a *Nitella* were followed in a control and an 80 per cent. CO experiment. The older cells of both were attacked by bacteria and killed, but the younger cells remained healthy. In the control the typical rotation was observed and

the cells appeared quite normal. In CO the younger cells while alive were paler than the normal and the peripheral layer of motionless protoplasm was enormously thick and apparently very much denser than in the usual condition. The chloroplasts were gorged with starch.

As a result then of progress already made in our experiments it may be said definitely that carbon monoxide, which has been hitherto considered neutral and without influence on plants, is in effect highly toxic when used to replace, partially or entirely, the nitrogen of the atmosphere. The experiments have not yet yielded sufficient detail to allow any determination of the point at which it ceases to be toxic, or to determine whether or not, like carbon dioxide, it stimulates growth when present in small proportions in the atmosphere. It has been shown, however, that a wide range of reaction to this substance is to be found among plants.

The deleterious action of the carbon monoxide results in modifications, of the rate and amount of growth, of the differentiations of the primary tissues, and of the formation of chlorophyl.

Illuminating gas, containing proportions of carbon monoxide slightly above and below 40 per cent., affords, in addition to the toxic action of the carbon monoxide, the results of the action of other substances deleterious to the plant.

The contents of this abstract will be published as soon as practicable, but the description of the details of the experimental tests and a consideration of the whole subject will await the conclusion of the investigation.

Additions to the flora of the Matawan formation

EDWARD W. BERRY

(WITH PLATES 1–5)

The following notes are based for the most part on collections made by the writer near Cliffwood, Monmouth County, New Jersey, during the spring and summer of 1903, although some of the material was collected the previous year.

This locality, in all probability, furnished the specimens described by Newberry in his Flora of the Amboy Clays as from "near Keyport." He did not, however, recognize it as a distinct horizon. Hollick in 1897 published a brief paper on this flora, recognizing twenty-six species from this locality. The writer in previous papers * increased this number to seventy-two and the present contribution raises the number of known species to eighty-five, most of which are represented by well-characterized remains.

A complete discussion of this flora is postponed for the present and will be included in a subsequent paper on the geology of the Matawan formation now in course of preparation.

No attempt has been made to give the synonymy except where the species mentioned is new to the flora.

FILICALES

GLEICHENIA ZIPPEI (Corda) Heer. (PLATE 4, FIGURE 6.)

Pecopteris Zippei Corda in Reuss, Verstein. 95. *pl. 49. f. 1.* 1846. Unger, Kreidef. Ostr. Sitz. Acad. Wien. 8. *pl. 2. f. 1.* 1867. Schimper, Pal. Vég. **1**: 672. 1869.

Gleichenia Zippei Heer, Fl. Foss. Arct. **1**: 79. *pl. 43. f. 4.* 1868; **3**: 44, 90, 97. *pl. 4, 5, 6. f. 1–3; pl. 7. f. 2; pl. 25. f. 1–3; pl. 26. f. 10–13.* 1874; **4**: 49. *pl. 32. f. 6, 7.* 1877; **6**[2]: 36. *pl. 3. f. 2.* 1882; **7**: 7. 1883. Newb. Fl. Amboy Clays, 37. *pl. 3. f. 5.* 1896. Ward, Ann. Rep. U. S. Geol. Surv. **19**[2]: 664. *pl. 162. f. 9.* 1899.

This widespread species is represented in our collections by a single poor specimen, much broken, and showing only the pinnules of one side. Easily distinguished from *Gleichenia Saundersii*

* Berry, Bull. N. Y. Bot. Gard. **3**: 45–103. *pl. 43–57.* 1903. American Naturalist, **37**: 677–684. *f. 8.* 1903.

Berry, from this formation, by the comparatively longer more rounded pinnules with more numerous secondary veins, nearly all of which are forked. The recorded range for this species is from the Neocomian to the Senonian, inclusive, in Europe, and from the Urgonian to the Cenomanian, inclusive, in this country.

GYMNOSPERMAE

GEINITZIA FORMOSA Heer. (PLATE 4, FIGURES 2, 3.)

Poorly characterized cones of this species were recorded by Hollick from this formation in 1897. Collections made during the past summer contain three characteristic twigs of this species. Leaves are upwards of 12 mm. in length, slender, averaging 1.2 mm. in width, much recurved; only spreading to about 5 mm. from the stem on each side.

Differs from the material described by Knowlton * from the Montana formation in the greater length of the leaves, which are also more slender and much more crowded; both have the thickened stem. Our specimens agree admirably with Newberry's figured specimen from the Raritan, which Knowlton (*l. c.*) considers positively identified. *Sequoia Reichenbachi* (Gein.) Heer from the Matawan formation is much more common, with more slender stems and less crowded leaves, which are also shorter and less recurved.

Pinus delicatulus sp. nov. (PLATE 1, FIGURE 12.)

The single specimen shows a large number of linear, pointed, apparently flat and ribbed, not terete or thickened, much broken and macerated leaves; of which none is apparently perfect. Some fragments are 12 mm. long and all are somewhat less than 1 mm. in width, and a midrib is plainly discernible in some of the fragments. While the illustration apparently shows needle-like leaves, they appear in the clay as of thin and delicate texture.

While these remains may appertain to the same species as the seed described by me from this formation, it has seemed best to keep them separate until they are found more nearly associated. There is considerable resemblance shown to Fontaine's *Laricopsis* of the Potomac formation in appearance and in the deciduous nature of their leaves.

* Knowlton, U. S. Geol. Surv. Bull. **163**: 28. *pl. 5. f. 1, 2.* 1900.

PROTOPHYLLOCLADUS SUBINTEGRIFOLIUS (Lesq.) Berry.* (PLATE 1, FIGURE 5.)

The Cliffwood specimen has the nervilles fine, .75–1.00 mm. apart, and shows no trace of a midrib, a feature which is scarcely defined in small leaves of this species, and wanting in several of Heer's figures, as well as in Hollick's leaf from Staten Island.

SEQUOIA GRACILLIMA (Lesq.) Newb. (PLATE 2.)

These cones are exceedingly common in the shingle on the beach after severe storms. Last summer's collections contain no less than thirty-nine specimens, many of which are of considerable size.

Following are the lengths of the largest specimens: 7.3 cm., 7.9 cm., 8.1 cm., 8.25 cm., 8.6 cm., 9 cm., 9.5 cm., 10.2 cm.

Plate 2 gives an excellent idea of the appearance and size variations of these cones. *Figure 3* is the least flattened by compression, being nearly round. The scales are hexagonal and in juxtaposition. Most of the specimens, however, are considerably flattened, the scales are somewhat separated, and they do not preserve their hexagonal outline with any degree of regularity. This is well shown in *figure 4*.

SEQUOIA REICHENBACHI (Gein.) Heer. (PLATE 4, FIGURE 8.)

The specimen figured is probably a small cone of this species, although there is considerable resemblance to some of the cones of the widespread *Sequoia Langsdorfii* (Brongn.) Heer, of the upper Cretaceous and Tertiary of both continents, which comparison is heightened by the finding at Cliffwood of a single detached leaf (*no. 506*) not figured or described, which seems referable to that species, but which may perhaps be a leaf of *Cunninghamites elegans* or *Sequoia heterophylla*.

DAMMARA CLIFFWOODENSIS Hollick. (PLATE 1, FIGURE 11.)

The proofs of my Matawan Flora were not revised until after I had collected the specimen here figured, and I removed the interrogation mark which Hollick placed after this species, as it seems more nearly allied to the scales of the existing *Dammara* than any of Heer's species.

* See Berry, Bull. Torrey Club, **30**: 440. 1903.

The specimen is an unusually perfect one and shows that the nearly straight lateral margins which become very thin are not usually preserved. There is no indication of the apical point figured by Hollick; on the contrary the apex is evenly rounded. In outline and size it is very similar to the scale from Tottenville, Staten Island, doubtfully referred by Hollick to *Dammara borealis* Heer. In the present collections these scales are not as abundant as in those of the previous season, although they still form a decided element in this flora.

CUNNINGHAMITES ELEGANS (Corda) Endl. (PLATE 3, FIGURES 7, 8, 9, 11.)

Last summer's collections contain numerous unmistakable fragments of this species, one a twig 7.7 cm. long.

CUNNINGHAMITES SQUAMOSUS Heer.

Remains of this species are not so common as in the previous season's collections, but several good specimens were collected including some twigs 8 cm. long. The portions of stems shown on *plate 5, figures 2* and *3*, are of this species or the preceding.

MORICONIA CYCLOTOXON Deb. & Ett.

Sparingly represented in the collections of 1903 by the same large-sized forms as those previously found.

FRENELOPSIS Schenk, Palaeont. **19**[1]: 13. 1869

Several species of Cretaceous plants have been referred to this genus, so named from their resemblance to the existing species of *Frenela* of the Australian region. The consensus of opinion seems to be that they are referable to the *Cupresseae*, although Heer is inclined to ally them with *Ephedra* among the *Gnetales*, and Schimper includes them in the *Taxaceae*. In lower Cretaceous times they ranged from the Mediterranean region of Europe to Greenland and North America, and their latest known appearance is in the Senonian of Westphalia. That these somewhat peculiar forms did not become extinct is evidenced by the remains referred to the closely allied, if not identical, genera *Widdringtonia*, *Widdringtonites* (*Frenelites*) and *Callitris* which occur both in Europe and in America, where they are common in the Creta-

ceous Atlantic coastal plain from New Jersey to Greenland. They persist as late as the Miocene, both in Europe (Bohemia, France, Germany and Italy) and in the Arctic region (Kudliset). Schenk (*l. c.*) calls attention to the great resemblance to *Frenelopsis* of the remains from the Italian Tertiary which Massalongo describes under the name of *Aularthrophyton* and of which Fontaine (1889) says: "It is difficult to believe that they belong to different genera."

The living genus is, according to modern usage, included in *Callitris* Vent., which as thus constituted becomes divisible into four sections: (1) *Octoclinis* (*Frenela* Benth.), (2) *Hexaclinis* (*Frenela* Mirb.), (3) *Pachylepis* (Brongn.) = *Widdringtonia* Endl., and (4) *Eucallitris* (Brongn.). The first two sections with some seven species are confined to the Australian region, while section 3 is confined to South Africa and Madagascar, and section 4 with one species, *Callitris quadrivalvis* Vent., is confined to the north coast of Africa. The habitat of the latter leads Coulter (1901) to suggest a recent avenue of migration through the southern Asiatic region, but it should be remembered that northern Africa was geographically and biologically a part of Europe in the upper Eocene, again in the lower Miocene, and finally during the early Pliocene, so that *Callitris quadrivalvis* might well be a relict of the similar species we find in the European Miocene. The South Africa and Madagascar forms may have traversed the ancient land connection between Africa and Asia in order to reach Australia, although their absence in the present Asiatic flora is remarkable if this was the route taken. It is quite possible that their actual migration was over the land bridge formed by the northerly extension of the continent Antarctica, which recent zoo-geographers are making so much use of (Blanford 1890, Forbes 1893, Osborn 1900).

The distribution of the *Cupresseae* as a whole, in past times as well as in the present, while a problem so intricate as to baffle our present knowledge, is one of exceeding interest.

FRENELOPSIS HOHENEGGERI (Ett.) Schenk. (PLATE 4, FIGURES 9, 10.)

? *Culmites priscus* Ett. Beitr. Fl. Wealdenp. 1[3]: 24. *pl. 1. f. 5* 1852.
Thuites Hoheneggeri Ett. *ibid.* 26. *pl. 1. f. 6, 7.* 1852.

Frenelopsis Hoheneggeri Schenk, Palaeont. 19[1]: 13. *pl. 4. f. 5–7; pl. 5. f. 1, 2; pl. 6. f. 1–6; pl. 7. f. 1.* 1869. Heer, Fl. Foss. Arct. 3: 73. *pl. 18. f. 5–8.* 1874; 6[1]: 7. *pl. 2. f. 1–3.* 1880; 6[2]: 16. 1882. Fontaine Proc. U. S. Nat. Mus. 16: 275. *pl. 42. f. 4, 4a.* 1893. Newb. Fl. Amboy Clays, 58. *pl. 12. f. 4, 5.* 1896.

This species which is common in the Urgonian of Austrian Silesia has been quite elaborately described and figured by Schenk (*l. c.*). If the various identifications of other authors are correct it was a widespread and persistent type, ranging from the Neocomian to the Turonian in Moravia, France, and Austrian Silesia, as well as in Greenland (Kome). In the United States it has been recorded from the Trinity of Texas and the Raritan of New Jersey, while very similar species occur in the Potomac of Maryland and Virginia. Its occurrence in the Matawan brings it down to a still later period. The Matawan specimens are numerous and fragmentary, and are distinguished with difficulty from the many fragments of other twigs preserved in the clays, all of which except the silicified forms have shrunk and have a more or less jointed appearance. All are decorticated and I fail to find any traces of leaves, but the regularity of the joints and the absence of longitudinal cracks in the larger specimens, which are always present in other twigs of similar size, has constrained me to refer them to the above species. Until material with positive traces of leaves is found this reference can only be provisional.

Gymnospermous Cone. (PLATE 4, FIGURE 7.)

I cannot conclude whether this is a cone with comparatively thin overlapping pointed scales, or whether it is a much-worn cone with thick-keeled scales which would then be inverted in the figure. The scales certainly seem to overlap in places, but this feature is much obscured, and I rather incline to the interpretation that we have a petrified cone of *Sequoia* which has washed out of the clay and become much reduced and worn smooth in the wash of the beach. As it stands it might be compared, except for its larger size, with the staminate strobili of *Podocarpus* or *Phyllocladus*. If it should prove to be a cone with imbricated pointed scales I would be inclined to associate it with the genus *Cunninghamites*, remains of which are so abundant in this formation. In this connection its resemblance to the cones described by Ettings-

hausen as *Cunninghamites Sternbergii*, from the synchronous horizon of Niederschöna, Saxony, is perhaps more than suggestive.*

ANGIOSPERMAE

MYRICA Linn. Sp. Pl. 1024. 1753

A cosmopolitan genus at the present time, except for the Australian region (Notogaea), although remains referred to this genus have been described by Ettingshausen from the Tertiary of eastern Australia and New Zealand.

The existing species number about three-score and are wide-ranging, the same species thriving within wide limits of climate and soil conditions. As might be expected from its scale of organization, *Myrica* is abundant during the Cretaceous, showing its greatest display of extinct forms in the Tertiary, however. Well represented in the fossil floras of Europe, Schimper thirty years ago records eighty-six species of leaves and one of fruit, mostly from European localities, where they make their greatest display somewhat later in the Tertiary than they do in America. The fossil species found on this continent number some seventy forms, distributed as follows: Potomac 1; Raritan (N. J.) 8; Raritan (Islands) 3; Dakota 10; Atane 5; Patoot 3; Montana 2; Laramie 2; Eocene 11; Green River group 19; Miocene 4; Miocene (so-called) of Greenland 9.

Eighteen of these forms are common to Europe.

Myrica Cliffwoodensis sp. nov. (PLATE 4, FIGURE 1.)

This species is founded on a single drupe or nutlet, which is 4.1 mm. in diameter, and which is almost certainly referable to *Myrica*. Although slightly flattened by pressure, it was evidently globose and had a short stem, somewhat under 2 mm. in length. While it may appertain to *Myrica Heerii* Berry, the only species represented by leaves in this formation, we cannot be certain of this and it was thought best to keep it separate.

Seeds, so called, of *Myrica* are reasonably common as fossils, of which the following have come to my notice:

* Ettings. Kreidef. v. Niederschöna: Sitzb. Akad. Wiss. Wien, **55**[1]: 12. *pl. 1. f. 4-6.* 1867.

Ludwig, 1858, describes them from the Miocene lignite beds of Wetterau at Dorheim in Hesse, and Engelhardt, 1870, detects the same species (*Myrica granulosa*) in the Tertiary of Saxony, at Quatitz and Kleinsaubernitz.

Heer, 1859, describes fruits of *Myrica Ungeri* from the Miocene of Switzerland.

Heer, 1868, refers fruit and leaves from the Tertiary of North Greenland (Atanekerdluk) to *Myrica acuminata* Unger.

Heer, 1869, describes seeds in the same clays with the leaves of *Myrica Schenkiana* from Quedlinburg (Senonian). The same year Heer describes fruit from Rixhöft which he referred to *Myrica Studeri* and from Rauschen which he referred to *Myrica* (*Comptonia*) *Vindobonensis* both from the Baltic Amber (Oligocene).

Saporta, 1866, discovered the fruit of *Myrica hakeaefolia* in the French Miocene at Armissan.

Lesquereux, 1874, describes stems and seeds from the Dakota group of Nebraska (*Myricae*? semina).

Heer, 1874, describes seeds and leaves from Atanekerdluk, Greenland (Cenomanian) under the name of *Myrica Thulensis*.

Lesquereux, 1878, describes as *Carpites Myricarum*, seeds found with the leaves of *Myrica Torreyi* at Black Buttes, Wyoming (Laramie).

Heer, 1882, describes fruit from Ivnanguit, Greenland (Cenomanian).

Heer, 1883, figures the fruit of *Myrica* (*Comptonia*) *parvula* Heer from the Patoot beds (Senonian) of Greenland.

Velenovsky, 1883, describes and figures catkins and fruit of *Myrica* from the Cenomanian of Bohemia.

POPULITES TENUIFOLIUS Berry.

A single leaf of this species collected on July 29, 1903.

QUERCUS HOLLICKII Berry. (PLATE 3, FIGURES 4, 5.)

The present season's collection contains two specimens of this species in which the margin is less serrate and more inclined to be crenate, characters which are not very well brought out in the plate. They show some resemblance to *Celastrophyllum crenatum* Heer, but have a more ascending base and straighter secondaries.

Quercus eoprinoides sp. nov. (PLATE 4, FIGURE 11.)

Leaf ovate-lanceolate, about 10 cm. long by 3.5 cm. in greatest width; coarsely toothed, the rounded teeth becoming mere undulations toward the base; secondaries straight craspedodrome, leaving the midrib at an angle of about 35°; venation much obscured; leaf-substance apparently thin but coriaceous in texture.

Among the fossil leaves of this genus, ours shows some resemblance to the *forma obtusata* of *Quercus Westfalica* of Hosius & von der Marck (Senonian). In size and outline it may be compared with *Quercus flexuosa* Newb. from the Cretaceous of

Washington (state) and with *Quercus Lyellii* Heer from the Greenland Tertiary, both of which however have camptodrome venation. A leaf-fragment from the Laramie of Yellowstone Park termed by Knowlton *Phyllites* sp.* also seems to be quite similar.

Among the living species of oaks this Matawan species bears considerable resemblance to some of the leaves of the hybrid *Quercus Rudkinii* Britton, which may be found growing within a short distance of where the fossils were obtained. The living species has the venation camptodrome, however. The resemblance to *Quercus prinoides* Willd. in size, outline, and venation is most striking; the only difference being the tendency of the modern leaves to become wider and more decidedly toothed; numerous identical leaves may be found, however. *Quercus prinoides* has a wide range throughout the United States, mostly east of the Mississippi river, and may be phylogenetically related to the Matawan leaf.

FICUS ATAVINA Heer. (PLATE 1, FIGURES 8, 9; PLATE 3, FIGURE 6.)

Ficus protogaea Heer (non Ettingshausen, 1867), Fl.. Foss. Arct. **3**: 108. *pl. 29. f. 2b; pl. 30. f. 1–8.* 1874. Hollick, Bull. Torrey Club, **21**: 51. *pl. 175. f. 4.* 1894.

Ficus atavina Heer, Fl. Foss. Arct. **6²**: 69. *pl. 11. f. 5b, 7b, 8b; pl. 17. f. 8b; pl. 19. f. 1b; pl. 20. f. 1, 2.* 1882. **7**: 26. 1883.

Remains of several leaves of this species have been found at Cliffwood recalling the handsome leaves of the commonly cultivated *Ficus elastica* Roxb. with which Heer originally compared it along with *Ficus Benjaminea* and *F. stricta.* There is considerable resemblance to *Ficus Krausiana* Heer, which is recorded from the Dakota group of Kansas, the Raritan of New Jersey and Marthas Vineyard, as well as from the Cenomanian at Moletein, Moravia. The latter species is however more ovate. Our leaf is almost the counterpart in size, outline and venation of *Ficus Peruni* Velen. from the Cenomanian of Bohemia. The venation of his *figure 2* is identical with the Matawan leaf figured at *6* on our *plate 3.* Velenovsky compares *F. Peruni* with the living *Ficus nitida* Thunb. and *F. cuspidata* and *F. pulchella* Schott. He compares it with the fossil *F. Krausiana* Heer, and with the species we are considering.

* U. S. Geol. Surv. Monogr. **32²**: *pl. 78 f. 7.* 1899.

MAGNOLIA SPECIOSA Heer. (PLATE 3, FIGURE 10.)

Magnolia speciosa Heer, Neue Denksch. Schw. Gesells. **23**: 20. *pl. 6. f. 1; pl. 9. f. 1; pl. 10. f. 1.* 1869. Lesq. Cret. & Tert. Fl. 72. 1874. Fl. Dak. Group, 202. *pl. 60. f. 3, 4.* 1892. Hollick, Trans. N. Y. Acad. Sci. **12**: 234. *pl. 7. f. 4.* 1893. Bull. Torrey Club. **21**: 60. *pl. 178. f. 5.* 1894. Bull. Geol. Soc. Am. **7**: 13. 1895. Knowlton in Hill, Ann. Rep. U. S. Geol. Surv. **21**[2]: 318. 1901.

Described originally from the Cenomanian of Moravia (Moletein), it has been identified at various localities in the Dakota Group, Tuscaloosa, and Island Raritan. It has not as yet been detected in the Cenomanian of Greenland, although some of Heer's figures of *Magnolia Capellinii* are suggestively similar; the latter species is, as a rule a wider, more robust leaf.

Magnolia speciosa seems related to a group of leaves exemplified by *Magnolia pseudoacuminata* Lesq., of the Dakota; *M. tenuinervis* Lesq., as identified by Knowlton from the Montana formation; *M. amplifolia* Heer, from Moletein and the Dakota, and *M. Californica* Lesq., from the Tertiary.

MAGNOLIA CAPELLINII Heer. (PLATE 3, FIGURE 3.)

Magnolia Capellinii Heer, Phyll. Crét. Nebr. **21**. *pl. 3. f. 5, 6.* 1866. Fl. Foss. Arct. **3**: 115. *pl. 33, f. 1–4.* 1874; **6**[2]: 90. *pl. 24. f. 3–5; pl. 25. f. 1–3; pl. 45. f. 1.* 1882. Lesq. Rept. on Clays, N. J. 29. 1878. Fl. Dak. Group, 203. *pl. 66. f. 1.* 1892. Velenovsky, Fl. Boehm. Kreidef. **3**: 20. 1884. Hollick, Trans. N. Y. Acad. Sci. **12**: 234. *pl. 6. f. 6.* 1893. Bull. Geol. Soc. Am. **7**: 13. 1895. Dawson, Trans. Roy. Soc. Canada, **11**[4]: 63. *pl. 11. f. 49; pl. 13. f. 49a.* 1894.

Lesquereux in 1878 identified this species from the perishable material collected by Professor Cook at Sayreville, N. J., but it has not since been reported from the Raritan. None of Newberry's Amboy Clay material was of this species, although he made particular search for it. It should be remembered, however, that the majority of his specimens were from other horizons in the Raritan than the one at Sayreville. This is a characteristic Cenomanian species occurring not only in the Dakota, but in beds of this age in Greenland and in Bohemia.

MAGNOLIA TENUIFOLIA Lesq. (PLATE 1, FIGURE 7.)

A well-defined fragment of a large-leaved *Magnolia* with slender veins, referred to the above species because of other remains of this species found here.

LIRIODENDROPSIS Newb. Fl. Amboy Clays, 82. 1896

Comparatively small simple emarginate leaves of the mid-cretaceous, which are ancestral to the more typical species of *Liriodendron*. In view of the wide limits of variation exhibited by the living descendant of these early forms, I am inclined to question the wisdom of generic separation, particularly as the lines of demarcation between the species of the *simplex-primaevum* group have not been, nor can they be, closely drawn.

Saporta has described remains from the Cenomanian of Padrão Portugal, under the name of *Chondrophyton laceratum* * which Ward renames † *Liriodendropsis lacerata* and which he considers very close if not identical with the leaves of this type from the Raritan. I cannot concur in this reference. The remains in question are very vague. Saporta figures two possible interpretations, which are quite dissimilar both in venation and in the character of the apex; and the veins, both secondary and tertiary are depicted as running directly to the margin. The parallelism between the Cretaceous flora of Portugal and that of the United States is close and there is no reason why this type of plant may not have evolved independently in both regions, although in my opinion the remains do not, as yet, corroborate this supposition.

LIRIODENDROPSIS ANGUSTIFOLIA Newb. (PLATE 4, FIGURE 4.)

Liriodendropsis angustifolia Newb. Bull. Torrey Club, **14**: 6 (in part). *pl. 62. f. 4.* 1887. Fl. Amboy Clays, 84. *pl. 53. f. 8.* 1896. Hollick, Trans. N. Y. Acad. Sci. **12**: 235 (in part). *pl. 5. f. 3?; pl. 7. f. 3.* 1893. Bull. Geol. Soc. Am. **7**: 13. 1895.

While the absence of the apex makes this reference provisional in view of minor differences in form and venation, I am inclined to so refer it. It is a species we would naturally expect to find in this formation because of its abundance in the Raritan both in New Jersey and the Islands.

LAURUS PLUTONIA Heer. (PLATE 3, FIGURE 1.)

A thick lauraceous leaf common at Cliffwood.

LAURUS HOLLICKII Berry. (PLATE 3, FIGURE 2.)

This species appears to be fairly common at Cliffwood.

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* Saporta, Fl. Foss. Port. 219. *pl. 38. f. 4, 5.* 1894.

† Ward, Rep. U. S. Geol. Surv. **16**: 540. 1896.

LAURUS PROTEAEFOLIA Lesq. (PLATE 1, FIGURE 10.)

The leaf figured is of lauraceous texture and denotes a somewhat more slender leaf than Lesquereux's type specimens. The specimen figured was accidentally destroyed.

SASSAFRAS PROGENITOR Newb. (PLATE 1, FIGURE 3.)

Sassafras progenitor Newb.; Hollick, Bull. Torrey Club, **21**: 53. *pl. 174. f. 1.* 1894. Bull. Geol. Soc. Am. **7**: 13. 1895. Newb. Fl. Amboy Clays, 88. *pl. 27. f. 1–3.* 1896. Berry, Bot. Gaz. **34**: 442. 1902.

While it may seem unwise to illustrate and include such an incomplete fragment, the exploitation of such imperfect specimens may often be of more importance in the study of ancient floras than that of more perfect and precisely definable remains. The specimen figured, which was the only one found, shows a part of the central and lateral lobes of a leaf that agrees fairly well with this species (compare with Newberry's *fig. 2*). This is probably a true species of *Sassafras*.

SAPINDUS MORRISONI Lesq.

The present season's collections contain larger leaves of this species than those found in this formation in 1902.

CELASTROPHYLLUM NEWBERRYANUM Hollick.

Hollick obtained this species at Cliffwood a number of years ago. It was not contained in my 1902 collections, but a single specimen was collected on July 29, 1903.

EUCALYPTUS GEINITZI Heer. (PLATE 4, FIGURE 5.)

The specimen figured from my 1903 collections is more decisive than the one previously found at this locality, and shows considerable details of venation. It is a fragment 6.8 cm. long of a linear, somewhat falcate leaf nearly 2 cm. in width, with numerous secondaries which leave the midrib at a wide angle and run without curving nearly to the margin, along which they loop in flat arches. This species resembles somewhat the leaf referred by Saporta and Marion and by Hollick to *Aralia transversinervia*, which leaf is almost certainly not an *Aralia*. It also resembles a single lobe of what I have called *Sterculia Cliffwoodensis* from this formation.

ARALIA RAVNIANA Heer.

The present season's collections contain a single, somewhat indefinite specimen of this species.

ARALIA PALMATA Newb. (PLATE 4, FIGURE 12.)

This was apparently a common species in Matawan times, if we may judge from the abundance of leaf fragments in the clays. The present season's collections contain numerous fragments of this leaf. The one figured I refer doubtfully to this species. It is certainly the same as *no. 6* of last year's collection, but both differ from the typical leaves in their straight secondaries.

ANDROMEDA PARLATORII Heer. (PLATE 1, FIGURES 1, 2.)

Well-characterized remains of doubtful botanical affinity common throughout the Cenomanian of the United States and Greenland. They are particularly abundant in the Raritan formation and the Matawan leaves here figured are the counterpart of several figured by Newberry. They are larger than the leaves from the Dakota group or from Greenland, and are also larger than the Matawan leaves of this species collected in 1902. The secondaries are less numerous and more regularly arched than in Newberry's Raritan leaves.

VIBURNUM Linn. Sp. Pl. 267. 1753

The American fossil forms which are referred to this genus number some forty-seven species, exclusive of seven varieties described by Lesquereux; two of these species occur in Spitzbergen and one on the Island of Sachalin. They have the following distribution: Raritan 1, which is obviously not a *Viburnum;* Dakota 6, plus 7 varieties; Patoot 3; Montana 4; Laramie 7; Denver 4; Eocene 2; Fort Union 17; Miocene of U. S. 2; of Greenland 3; Tertiary of Tongue River (Yellowstone Park) 3. Their distribution marks North America as the original home of the genus; they reached Alaska in the Eocene and crossing the emerged belt where Behring Straits now stand, are found in the Eocene or Oligocene of Sachalin Island. Toward the north and east we find them in Greenland in the Senonian (Patoot) and in Spitzbergen in Heer's "Miocene," which is Eocene or Oligocene.

Three species occur here, two of which are common to Greenland. On the continent of Europe we have one species in the Vraconnian, one in the Senonian, and the balance, which are few in number, Tertiary or recent.

The early appearance of *Viburnum*, one of the *Sympetalae*, associated with *Aralia*, both epigynous forms, suggests to Coulter * a connection of the *Umbellales* with the *Sympetalae* not admitted in current schemes of taxonomy.

Some have been led to doubt the authenticity of the reference of the Cretaceous forms to this genus. It may be noted, however, that most of them have leaves with well-marked characters, which are emphasized by undoubted remains of fruit in a number of instances. The majority of the *Sympetalae* are herbaceous and unsuited for fossilization, while *Viburnum* is shrubby and inhabits swamps and the banks of streams, thereby offering excellent opportunities for preservation. That it is a type of long standing is evidenced by the number of existing species, by the abundance of individuals, and their wide range. They number upwards of one hundred, of subtropical and temperate eastern Asia and North America; Europe has but three species, two of which occur in northern Africa. A probably distinct phylum (*Oreinotinus* Örsted) of about thirty species inhabits Central and South America along the Andes, two of the species being common to Jamaica.

Viburnum Mattewanense sp. nov. (PLATE 4, FIGURE 13.)

A single imperfect specimen of a leaf clearly referable to this genus, and differing from *Viburnum Hollickii* Berry from this formation in its more broadly oval outline and more decided marginal teeth; the ascending basal secondaries are wanting and the first pair leave the midrib at an angle more than twice as great as in *V. Hollickii*.

Leaf 7 cm. wide and between 10 and 11 cm. in length; substance thin; secondaries slender and curved, more remote than in the existing species; lower outside branches of the first secondary have their tips united by a thin vein parallel with the secondary, indicating that the basal portion of the margin was entire; distad the tertiaries curve directly to the marginal teeth; balance of the tertiaries percurrent at right angles to the secondaries.

* Coulter, Morphology of the Angiosperms, 1903.

INCERTAE SEDIS

TRICALYCITES PAPYRACEUS Newb. (PLATE 1, FIGURE 4.)

Tricalycites papyraceus Newb.; Hollick, Bull. Torrey Club, **21**: 63. *pl. 180. f. 1 (?), 8.* 1894.

A well defined organism of unknown affinity, dicotyledonous according to Hollick. Consists usually of a small nucleus with three membranous wings and is very common in the Raritan of New Jersey, occurring also on Staten and Long Islands, Chappaquidick and Block Islands, also occurring in the Tuscaloosa formation of Alabama. From the Matawan I have obtained but a single specimen of but one wing. *Tricalycites* is probably comparable with the bracts so largely developed in some of the *Juglandaceae* and *Betulaceae.*

CARPOLITHUS JUGLANDIFORMIS Berry.

Carpolithus juglandiformis Berry, Bull. N. Y. Bot. Gard. **3**: 100. *pl. 46. f. 8.* 1903.

Carpolithus dubius Berry, Bull. N. Y. Bot. Gard. **3**: 100. *pl. 48. f. 7.* 1903.

The remains named by me *Carpolithus juglandiformis* in drying and shrinking away from the matrix leave an impression exactly similar to that of *Carpolithus dubius*, showing that both appertain to the same plant and are the remains of nut-like fruit with a striated husk, the botanical affinity of which I have not been able to conjecture. They show considerable resemblance in a general way to what Newberry* calls *Tricarpellites striatus*, and which occur abundantly in the Raritan formation at Woodbridge, N. J. The Matawan remains fail to show any pointed apex and have not been found associated in threes, or with any indication of such association. *Plate 46, figure 8* (Berry, *l. c.*) evidently hints at the internal structure but in too vague a manner for discussion.

Coniferous Stem. (PLATE 5, FIGURE 5.)

This is an interesting and unique specimen recalling the genus *Lepidodendron* of the Paleozoic. It represents a portion of a stem at the juncture of a branch, the leaf-scars of which were much hollowed out by decay before fossilization.

Prof. Lester F. Ward, to whom the specimen was submitted, suggested its possible relation to *Cunninghamites*, because of the latter's abundance in the Matawan formation.

* Newb. Fl. Amboy Clays, 132. *pl. 46. f. 9–13.* 1896.

It may be compared with our *plate 5, fig. 2*, which represents a branching stem similar in size and outline; the latter is silicified and retains remains of the attached leaves, rendering it reasonably certain that it is a portion of a stem of *Cunninghamites*.

Although comparisons are impossible because of the destruction of the type specimen, Dr. Hollick suggests that his *Strobilites inquirendus* from this formation may represent a distorted section of a stem like the one here figured.

PASSAIC, N. J.

Explanation of plates

PLATE 1

FIGS. 1, 2. *Andromeda Parlatorii* Heer.
FIG. 3. *Sassafras progenitor* Newb.
FIG. 4. *Tricalycites papyraceus* Newb.
FIG. 5. *Protophyllocladus subintegrifolius* (Lesq.) Berry.
FIG. 6. *Sassafras acutilobum* Lesq.
FIG. 7. *Magnolia tennifolia* Lesq.
FIGS. 8, 9. *Ficus atavina* Heer.
FIG. 10. *Laurus proteaefolia* Lesq.
FIG. 11. *Dammara Cliffwoodensis* Hollick.
FIG. 12. *Pinus delicatulus* sp. nov.

PLATE 2. (Reduced one tenth)
Cones of *Sequoia gracillima* (Lesq.) Newb.

PLATE 3
FIG. 1. *Laurus plutonia* Heer.
FIG. 2. *Laurus Hollickii* Berry.
FIG. 3. *Magnolia Capellinii* Heer.
FIGS. 4, 5. *Quercus Hollickii* Berry.
FIG. 6. *Ficus atavina* Heer.
FIGS. 7–9, 11. *Cunninghamites elegans* (Corda) Endl.
FIG. 10. *Magnolia speciosa* Heer.

PLATE 4
FIG 1. *Myrica Cliffwoodensis* sp. nov.
FIGS. 2, 3. *Geinitzia formosa* Heer.
FIG. 4. *Liriodendropsis angustifolia* Newb.
FIG. 5. *Eucalyptus Geinitzi* Heer.
FIG. 6. *Gleichenia Zippei* (Corda) Heer.
FIG. 7. Gymnospermous cone.
FIG. 8. *Sequoia Reichenbachi* (Gein.) Heer.
FIGS. 9, 10. *Frenelopsis Hoheneggeri* (Ett.) Schenk.
FIG. 11. *Quercus eoprinoides* sp. nov.
FIG. 12. *Aralia palmata* Newb.
FIG. 13. *Viburnum Mattewanense* sp. nov.

PLATE 5. (Reduced one tenth)
FIGS. 1, 5. Coniferous stems.
FIGS. 2, 3. Stems of *Cunninghamites*.
FIG. 4. Unknown organism.

Concerning some West American smuts

David Griffiths

Many of the following notes and descriptions have been prepared for nearly a year and are based mainly upon collections made in 1902 and 1903. The extensive territory visited during these two years has naturally yielded unrecorded species as well as furnished additional data regarding imperfectly known forms. This writing furnishes descriptions of only a part of the new species collected.

The writer is indebted to Professor G. P. Clinton for his kindness in examining and giving critical judgment upon many of the species mentioned here. All the specimens discussed will be found in the U. S. National Herbarium and in my private collection. Nearly all of them are also in Professor Clinton's private herbarium.

Sorosporium contortum sp. nov.

Sori involving the entire upper internode and head which are transformed into a cylindrical or fusiform black compact mass, the spore-balls wearing away from the outside gradually by abrasion or becoming reduced to a powdery mass within the unopened sheath, very variable in length, 5–30 mm. by .6–1.5 mm., completely enclosed within the upper sheath, the internode and head being reduced to a comparatively very short columella, the remainder of the cylinder consisting of the bases of the delicate, much contorted, partially developed awns; sterile membrane long-cylindrical and usually extending fully half its length beyond the sheath, the basal portion enveloping the sorus, but the exterior half or more sterile and containing only the distal parts of the awns, usually more or less contorted, rupturing easily, and becoming lacerated, giving to the plant a very ragged appearance; its cells hyaline, cuboidal to somewhat elongated with longitudinal, rib-like thickenings; spore-balls subglobose to ovoid, and often angular, many-spored, 50–62 μ by 50–80 μ; spores subglobose to angular-compressed, dark fuscous, 5–8 μ in diameter, with thin, smooth epispores, homogeneous contents, and usually very faint, central or eccentric nuclear area.

On *Andropogon contortus* L., Santa Rita Mountains, Arizona (within the area recently fenced by the U. S. Department of Agri-

culture), September 12, 1902 (type); Santa Rita Mountains, Arizona, October 1, 1902 (Griffiths & Thornber); Empire Ranch, Arizona, September 27, 1902 (Griffiths & Thornber).

This is a very common and conspicuous fungus throughout the Santa Rita Mountains. It was abundant in the type locality as well as on the south side of the mountains in 1903, but no collections were made of it. It usually destroys all of the heads on the bunch of grass which it attacks.

Sorosporium Eriochloae sp. nov.

Sori in ovary and surrounded by a sterile membrane which projects but slightly beyond the glumes of the host, its base surrounding the aborted pistil and black powdery mass of spores, but the distil end empty or containing only the distal portions of the aborted pistil; its cells hyaline, slightly longer than broad, upper portion early becoming lacerated and recurved; spore-balls subglobose, angular and very irregular in both outline and size, 50–65 μ by 50–105 μ, easily separable; spores dark fuscous, subglobose, 10–13.5 μ in diameter, angular, with thin, smooth epispore, coarsely granular contents and small but distinct nuclear area.

On *Eriochloa punctata* (Linn.) W. Hamilt., Empire Ranch, Santa Rita Mountains, Arizona, September 28, 1902 (Griffiths & Thornber). The material cited above is quoted as the type because it is more plentiful than other collections which the writer has made. It was collected by me in the spring of 1901 in native hay on the ranch of Col. H. C. Hooker in Sulphur Spring Valley, Arizona, and subsequently observed during the fall of 1903 in various localities in southern Arizona. It is a very common species.

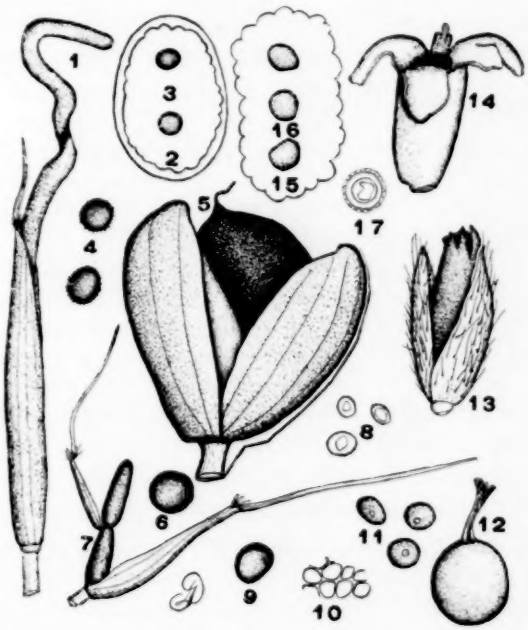
Ustilago lycuroides sp. nov.

Sorus in ovary which is inflated to a globular, olive green body, covered with the thin, wrinkled and modified integument, 1–1.5 mm. in diameter, bearing at its distal end the style and stigma but little modified, the interior being completely filled with a hard, brittle mass of spores which are brown, subglobose to slightly oval and angular, 9.5 to 13 μ in diameter; epispore thin, smooth, contents granular with a distinct central or eccentric nuclear area.

On *Lycurus phleoides* H.B.K., Santa Rita Mountains, Arizona, September, 1902 (Griffiths & Thornber). This appears to be a very rare species. Only a few smutty heads were found. The exact type locality is one mile north of Greaterville, on the road to Rosemont.

Ustilago calcara sp. nov.

Sorus circular, .5 mm. in diameter to linear and confluent, 5 mm. or more in length extending between the veins and erumpent upon the exterior of the modified, overlapping sheaths, and less frequently upon the leaves; internodes and culms in diseased host very much shortened and repeatedly branched, producing miniature witches' brooms; spores sooty, black in mass, irregular, globular to ovate, and often pointed, 7–10 μ by 7–10.5 μ with one



1. *Sorosporium contortum*, showing upper sheath and sterile membrane, × 2. 2. Outline of spore-ball, × 215. 3. Spores, × 315.

4. Spores of *Ustilago Scolochloae*, × 320.

5. *Tilletia pulcherrima* in spikelet of *Panicum obtusum*, × 12. 6. Spore, × 315.

7. Upper portion of culm of *Eragrostis Neo-Mexicana*, showing method of attack of *Ustilago strangulans*. Natural size.

8. Spores of *Ustilago calcara* on *Bouteloua breviseta*, × 315.

9. Spore-ball of *Thecaphora Thornberi*, × 35. 10. Portion of the spore-ball, × 315, showing outlines of the individual spores.

11. Spores of *Ustilago lycuroides*, × 315. 12. Ovary of the host distorted by the smut, × 8.

13. Spikelet of *Eriochloa punctata* showing distortion of ovary by *Sorosporium Eriochloae*, × 5. 14. Distorted ovary showing method of rupture, × 8. 15. Outline of spore-ball, × 215. 16. Spores, × 315.

17. Spore of *Tilletia Wilcoxiana*, × 320.

or more large, irregular, highly refractory central areas; epispore thin and smooth.

On *Bouteloua breviseta* Vasey, upon the gypsum deposits east of Roswell, N. M., May 4, 1903. This smut is very abundant in this region, but is easily overlooked because the effect upon the host is likely to be considered due to the work of insects. It is easily distinguishable from the other two species which appear on the leaves and culms of various species of the genus *Bouteloua*—first, by the effect upon the host; second, by the entire absence of pustules, which are always found in the other two species.

Ustilago Scolochloae sp. nov.

Fructification of the smut involving the leaves of the upper two to four nodes which are reduced to such an extent that the blades of the upper ones remain unopened, remainder of the plant nearly normal; sori normally epiphyllous, but sometimes hypophyllous in a few places on the inner, more delicate leaves; apparently confined to the blades and seldom if ever occurring on the sheaths, long, linear, often confluent the entire length of the leaf but the entire surface soon covered with the sooty mass of spores; spores subglobose, uniform in size and shape, 10–13 μ in diameter, dark, fuscous, but sooty black in mass, densely and uniformly covered with coarse, blunt tubercles.

On *Scolochloa festucacea* (Willd.) L., Donner & Blitzen River, Harney Valley, Oregon, July, 1902 (Griffiths & Hunter). Closely related to *Ustilago echinata* Schröt.

USTILAGO HYPODITIS (Schl.) Fr.

A very peculiar effect of this smut upon one of its common hosts was observed during the past season about 20 miles east of Roswell, N. M. *Distichlis spicata* is very commonly smutted with this species in fields and meadows near the Pecos river where it is reduced but little, if any, in size. In some of the salty ravines which lead up through the gypsum bluffs, however, the host appears to be very much reduced in size by the smut. The internodes are very much shortened and the whole plant reduced to an inch or two in length, with the leaves and sheaths reduced to bract-like structures or in some cases the upper two to four nodes confined within one swollen sheath, presenting an appearance not unlike the common smut upon species of *Hilaria*.

Specimens were collected here on the 7th of May and again on the 5th of September, showing the same effect but more pronounced at the earlier date.

The smut was especially destructive to *Stipa Vaseyi* in the Raton Mountains of Colorado and New Mexico during the past season.

There occurs in California a well-marked variety of this common species on a number of hosts, but it does not seem desirable to give it a name until field work determines whether the characters are constant, because the spores are not distinguishable from some of the common forms. The variation from the typical form on various species of the genera *Stipa*, *Agropyron* and *Elymus* is in the method of attack. Instead of the sorus being within the sheath it occurs on the leaf-blades and inflorescence which are more or less distorted by it. The writer has observed this method of attack on three hosts in California during the past two years. The first collection was made at Cedarville on *Puccinellia airoides* in July; the second on *Sitanion longifolium* in Jess Valley in August, 1902, by myself and Mr. Byron Hunter, and the third near Millwood upon two forms of *Elymus glaucus* by myself last June. In the first and last examples, especially, the hosts were in a very vigorous state of development and this phenomenon may be simply an expression of the vigor of the host. We can hardly suppose that there is difference enough in the structure of these species and their close relatives in the genera *Poa* and *Elymus* upon which the normal form occurs to cause this variation in the method of attack.

USTILAGO HIERONYMI Schröt.

This species is listed on two additional hosts *Bouteloua breviseta* Vasey, upon which it was found rather sparingly about 20 miles east of Roswell, New Mexico, in September, 1903, and *B. Havardii* Vasey in the Santa Rita Mountains, Arizona, October, 1902. It is often very destructive to the latter species throughout southern Arizona.

USTILAGO STRANGULANS Issat.

This has been observed in but one locality, on *Eragrostis Neo-Mexicana*, in the Santa Rita Mountains, Arizona, near Rosemont,

September, 1902, where it affected every plant upon an acre or more of ground in the vicinity of an old corral where the soil was thoroughly tramped.

Tilletia Wilcoxiana sp. nov.

Sorus produced in ovary of the host which becomes inflated to an olive green fusiform body, three or four times its normal size; spores light brown in mass, but hyaline by transmitted light, subglobose, 15–19 μ in diameter with a narrow, hyaline enveloping membrane but little exceeding the stout, blunt, uniformly distributed projections on the very thick epispore.

On *Stipa eminens Andersonii* Vasey, Santa Monica, California, Spring, 1901 (Dr. H. E. Hasse). Mr. E. N. Wilcox first discovered this smut while studying the genus *Stipa* (see Bot. Gaz. **34**: 66. 1902). The same host infested by the same species of smut was collected in the original locality by Dr. Hasse again in April, 1902. In all the material at hand the spores are slightly under mature and the description so far as it relates to the color of the spores may have to be modified later.

TILLETIA PULCHERRIMA E. & G.

A very destructive smut upon *Panicum obtusum* H.B.K. throughout southern Arizona. It has been observed in a dozen localities since the autumn of 1900. It is very easily overlooked. A collection of it was made on the Empire Ranch, Santa Rita Mountains, Arizona, September, 1902.

Thecaphora Thornberi sp. nov.

Sorus in ovary which is inflated more or less symmetrically to a spherical body 4–7 or more mm. in horizontal diameter which usually slightly exceeds the vertical, the modified tissues rupturing irregularly at maturity; spore-balls reddish brown in mass, 70–100μ by 80–120μ, oval, subspherical or sometimes compressed angular, opaque at maturity with the individual spores scarcely distinguishable; spores apparently inseparably united, with thin walls, granular contents, and without visible nuclear areas, about 10 by 13μ. When young the exterior walls of the spores appear slightly reticulated, but this is entirely lost at maturity.

On *Clathorix lanuginosa* Nutt., Santa Rita Mountains, Arizona, about four miles north of Helvetia on the Tucson road, October 4, 1902 (Griffiths & Thornber). It was abundant in this place but has not been observed elsewhere.

U. S. DEPARTMENT OF AGRICULTURE.

The mechanics of seed-dispersion in Ricinus communis

J. B. Dandeno

Seed-dispersion is a matter of such common knowledge that almost everybody has had some experience with some special adaptation exhibited by certain plants, one way or another. The more common agents which serve the plant's purpose are wind, water and animals. But there are various other means, not so apparent, and consequently not so well known, which contribute towards the well-being of the plant in its struggle for space (or room) in which to flourish.

One method, not so uncommon as is generally supposed, is here examined in some detail with a view towards gaining some definite knowledge in regard to the actual dynamics involved in the projection of the fruit. To illustrate this problem the castor bean was selected.

The advantage to a plant of some special means of transporting its seed is so apparent that it needs no comment. How the plant came to possess this special means, is a question which largely belongs to the problem of evolution, and is not here discussed.

To understand the whole question fully it is necessary to examine all the conditions. Each plant of the castor bean produces on an average about five flower-clusters, the axis of each cluster being nearly perpendicular to the ground. On each cluster there are about fifty-eight fruits, each borne on a peduncle which inclines about forty-five degrees to the vertical. The axis of each fruit is at right angles (approximately) with the peduncle and inclining towards the ground at an angle, therefore, of forty-five degrees with the vertical. At this angle, one of the fruit-parts (carpels) would be projected at an angle of forty-five degrees above the horizontal (theoretically the angle of projection which produces the greatest range). But, as the carpels commence to separate, they do so from the *base* of the fruit, thereby lessening the angle of that one carpel some five or ten degrees; and, since atmospheric conditions have to be taken into account, forty degrees is the angle which gives actually the greatest range, so it is easy to see that the plant has the best actual position to project its seed to the greatest

distance. The other two carpels cannot be in so good a position, but the plant appears to be able to sacrifice several in order that a *few* seedlings may obtain a place of advantage the following season. It sacrifices *two* carpels that *one* may have the maximum of benefit in this respect.

As the fruit ripens it loses water gradually and begins to split open septicidally from the base and keeps on splitting thus, until a point is reached about three millimeters from the apex. While this is going on, the carpels are not only separating from one another, but also from the central column which is a continuation of the fruit-stalk. On three sides of the apical end of this central column are the three placental processes. Each projects into the locule to some extent, but the seed breaks off early from the placenta, leaving this central column wholly separate from the three carpels, yet suspending them because the processes referred to extend into each carpel through a comparatively large opening near the apical end. The carpels are therefore suspended much in the same manner as if hanging upon a peg; but as the three are still joined together they cannot be separated entirely from the central column until *one* of the three is removed. This central column, upon separation from the carpels, is left with three projecting flanges which, together with the processes referred to, prevent any alteration in position of the fruit which might possibly result when the carpels become detached from the column. At first glance this would seem to make no difference; but, when we consider that the carpel *first* projected will have the greatest momentum it is of some importance. The carpel with its dorsal side uppermost will have the most sun exposure and will consequently dry out most quickly. This is the carpel which has the best position, and which will most likely reach the maximum range.

A second stage in the process of preparation for actual projection may be said to commence after the carpels are entirely free from the central column. As the carpel dries out, the dorsal wall contracts and this contraction produces a pressure which becomes greater and greater as contraction goes on until the carpel gives way at its weakest point. This is at the apical end, where there are three pairs of tooth-shaped arrangements meeting at a line about three or four millimeters long. Each carpel splits apart at this

line with some violence. This acts just as a spring suddenly relaxed; thus the carpel is projected. This splitting is a loculicidal dehiscence and the seed, though projected with the carpel, is at this time, or soon after, released, but not before.

Another structural peculiarity is the prickly surface of the carpel, and this might easily act in conjunction with the explosion, from the fact that any slight disturbance immediately before the carpels were ready to explode, would *cause* the explosion, and these carpels might then attach themselves to such animal as might produce the disturbance. This, however, is not taken into consideration.

To ascertain the magnitude of the energy of expulsion it was necessary first to determine the actual distance some of the carpellary parts were projected. This was done in-doors by hanging the mature fruiting branches in a natural position at a given distance, approximately that of the plant, above the horizontal, and then measuring the actual range which the carpels were projected. The plants in the garden were similarly examined and the results did not differ very materially from those obtained in-doors. The average distance from the vertical, of those carpels which seemed to be projected from the position most favorable of the three carpels, was found to be 3.65 meters, and the average height of the cluster was 1.6 meters. Then, since the angle of rising equals the angle of falling, the real horizontal range would be $3.65 - 1.6 = 2.05$ meters. Since the angle of projection is 40°, then $2v^2 . \sin 40° \div 9.8 = 2.05$ meters. $\therefore v = 3.6$ (approx.) meters per second, where v is the velocity of projection. Hence the work done in projecting a body weighing .4 grams (the weight of one carpel with contents) would be

$$\left(\frac{3.6}{9.8}\right)^2 \times 4.9 \times .4 = .264 \text{ gram-meters per sec.}$$
$$= .000264 \text{ kgm. per sec.}$$

Since there are 3 carpels to one fruit, and 58 (average) fruits on one cluster, and 4 (average) clusters on one plant, each plant would do, by the sudden "filliping" of the carpels,

$3 \times 58 \times 4 \times .000264 \div 76 = .0024$ horse powers per second.

And if each plant requires 4 square feet of ground space upon which to grow, on one acre there would be 10,890 plants; there-

fore, a measure of the work done in exploding the carpels of the plants on one acre would be

$$10890 \times .0024 = 26.14 \text{ horse-powers per second.}'$$

This simply means that the work done is equal to that which one good strong horse could do in 26 seconds. It does not mean the energy that might be required in threshing out the seeds, but it means that energy alone which *causes* the *projection* of the carpels.

It should also be observed that the calculated range was an approach toward a maximum rather than an average, because no account was taken of the fruit which seemed to have simply fallen, or of those projected from a disadvantageous position, although the energy in the latter case would undoubtedly be the same as that exerted in the projection of those which had been discharged from a position of advantage.

The energy expanded by the plant is developed directly from the atmosphere, coupled with the heat of the sun; and indirectly from the cells and contents built up by the plant. Indeed, it is the same quality of energy as that which raises water from the earth into the atmosphere. The part taken by the plant is the preparation of carpels of such a form as will store up this energy for a time and thus make the best use of it by liberating it *all at once*. What this means to the species in successfully contending for space in which to grow, may be best illustrated by a mathematical calculation.

Starting with a given plant, it may be seen from our measurements that the ground covered by the seedlings from this plant would be

In 1 year $3.65^2 \times \pi$ square meters,
In 2 years $7.30^2 \times \pi$ square meters,
In 3 years $10.95^2 \times \pi$ square meters,
In 100 years $365^2 \times \pi = 41.8707$ hectares $=$ 105 acres (approx.).

This does not seem to be a very large area when the length of time is taken into consideration; but it must be borne in mind that this is only *one* means the plant has for scattering its seed. It takes no account of the washing away by water, or the transportation by wind or animals. The calculations are made upon the consideration of the fruit as a *projectile* alone, and from this the attempt is made to see just how much it has to do with the well-being of the plant.

Notes on Bahaman algae

MARSHALL A. HOWE

(WITH PLATE 6)

A collection of Bahaman algae, mostly marine, secured during the summer of 1903, by Dr. W. C. Coker, of the University of North Carolina, chief of the botanical staff of the Expedition of the Geographical Society of Baltimore to the Bahama Islands,* has been submitted to the writer for determination. This collection includes several rare or novel forms and some of the more interesting have been selected for comment below. Dr. Coker's specimens of algae were all preserved in fluids, either alcohol or solutions of formaldehyde, and they have for this reason proved especially satisfactory for study; though in some cases, as may necessarily happen, the material was less copious than could be desired.

Caulerpa compressa (Web.-v. Bosse).

Caulerpa paspaloides, var. *typica*, f. *compressa* Web.-v. Bosse, Ann. Jard. Bot. Buitenzorg, **15**: 353. *pl. 30. f. 3, 4.* 1898.

In four feet of water, off Clarence Harbor, Long Island, Bahamas, July 16, 1903.

This plant, which agrees closely with Mme. Weber's description and figures, is, we believe, absolutely distinct from *Caulerpa paspaloides* (Bory) Grev. In *C. paspaloides*, the primary pinnules are 3- or 4-ranked, so that the "frond" is distinctly 3- or 4-angled or 3- or 4-winged, a character that is more strikingly apparent in fresh or fluid-preserved material than in dried specimens; the secondary pinnules are pectinately secund along the upper side of the rachis and the lowermost of these secondary pinnules are always much shorter than the rachis itself. In *Caulerpa compressa*, on the other hand, the primary pinnules are so numerous and densely crowded that it is difficult to say how they are arranged, but they are probably 8–12-ranked, and the "frond" is as cylindrical and dense as that of *Dasycladus vermicularis* (Scop.) Krasser; the sec-

* For organization of this expedition and outline of its results, see *Science*, II. **18**: 427. 20 1903.

ondary pinnules are pinnately distichous and corymbose, the lowermost being as long as the rachis or slightly longer; the "pedicel" supporting the four, five, or more digitate primary branches or "fronds" is very short, measuring in Dr. Coker's specimen only 0.5–1.0 cm.

CAULERPA PASPALOIDES (Bory) Grev.

Green Cay, in 4 fathoms.

RHIPOCEPHALUS PHOENIX (Ell. & Soland.) Kuetz.

Mangrove Cay, Andros, June 26, 1903. Dr. Coker's specimens accord very well with Ellis's original figure * in regard to the outline of the capitulum, but the flabella are broader, more crowded, and more erect. Specimens collected by the writer at Key West, Florida (*no. 1612*, distributed in Phyc. Bor.-Am. as *no. 1030*) are extremely varied as regards the form of the capitulum, only occasionally offering the oblong-ovoid outline figured by Ellis. The capitula of some of these Key West plants are conical, some are broadest near the top, tapering down to the stalk below, and others are much elongated and of uniform width throughout (sometimes 9–10 cm. × 1–1.5 cm.), but these extremes are connected by clearly intermediate forms and we think but one species is represented.

UDOTEA CONGLUTINATA (Ell. & Soland.) Lamour.

Collected by Dr. Coker at several points; at Green Cay in 4 fathoms of water. **Udotea Flabellum** (Ell. & Soland.),† which is much the more common in southern Florida and Porto Rico, does not appear to have been found by Dr. Coker.

MICRODICTYON CRASSUM J. Ag. Anal. Alg. Cont. 1: 107. 1894.

Green Cay, in 4 fathoms. We are using provisionally for these plants collected by Dr. Coker the specific name applied by J. Agardh to specimens from the Bahamas sent to him by Mrs. Curtiss, though it is not yet wholly clear how either are to be kept separate from *Microdictyon umbilicatum* (Velley) Zanard. J. Agardh in proposing *M. crassum* as a new species appears to have

* Ell. & Soland. Nat. Hist. Zooph. *pl. 25. f. 2.* 1786.

† *Corallina Flabellum* Ell. & Soland. Nat. Hist. Zooph. 124. *pl. 24.* 1786. *Udotea flabellata* Lamour. Hist. Polyp. 311. 1816.

been influenced chiefly by the "articulis multo brevioribus quam in aliis speciebus" * * * * * "diametro vix longioribus." But the articuli of the original *Conferva umbilicata* as figured by Velley (Trans. Linn. Soc. **5**: *pl.* 7. 1800) are also often "diametro vix longioribus," even though J. Agardh * describes the articuli of *Microdictyon umbilicatum* as "circiter 4-plo longioribus." Velley's specimens were from New South Wales, and J. Agardh's remark, "Quae prima vice ad insulas Sandwich detecta fuit *C. umbilicatis*, eandem quoque ad Novam Hollandiam obvenire statuit C. Agardh (*Syst. p. 85*)," seems to indicate that he had seen neither the original plants nor the original description and figures of the first-described species of the genus.

Coccocladus † **occidentalis laxus** var. nov.

Fertile plants reaching 7 cm. in height and 10–13 mm. in width, flaccid: sporangia obovoid, oblong-ellipsoidal, or pyriform-subclavate, 460–880 μ × 315–430 μ, often twice as long as broad, lateral or occasionally terminal at the ends of branches of the first three (rarely four) orders: aplanospores for a long time closely coherent in a single peripheral layer surrounding a central cavity, radially elongated, 66–85 μ × 55–72 μ, mostly 1½ times as long as broad, usually angular-obovoid or ellipsoidal. (PLATE 6, FIGURES 1 AND 2.)

In small sink-holes by Big Pond, Nassau, June 23, 1903.

This remarkable plant is so strikingly different from the usual form of *Coccocladus occidentalis* as to suggest at first sight not only a distinct species, but even a different genus, yet in the presence of some apparently intermediate forms from other collections we dare not propose for it a rank higher than that of variety; though it is possible that a fuller knowledge of its life-history would lead to another conclusion. Dr. Coker writes that the plant grows "about one mile inland," in slightly brackish water which responds to the changes of the tide. The lax habit, the elongated sporangia, and extension of the sporangium-bearing capacity to

* *l. c.* 105.

† COCCOCLADUS Cramer, Neue Denkschr. Schweiz. Naturf. Ges. **30**: —(37). 1887.

Botryophora J. Ag. Till Alg. Syst. 5: 139. 1887. Wille, E. & P. Nat. Pflanzenfam. 1^2: 157. 1891. Not *Botryophora* Bompard, Hedwigia, **6**: 129. 1867. The generic type of *Coccocladus*, as also of J. Agardh's *Botryophora*, is *Dasycladus occidentalis* Harv. Ner. Bor.-Am. 3: 38. *pl. 41B*. 1858.

branches of the third (and even the fourth) order are in harmony with the variations which the recent researches of Dr. Livingston * might lead us to expect would occur in a transition from salt to fresh or slightly brackish water. The variety *laxus* is almost destitute of the yellowish staining matter which manifests itself so conspicuously in ordinary specimens of this genus whether dried or preserved in fluids. In all conditions of *Coccocladus*, the sporangia appear to mature almost simultaneously in all parts of a plant, so that a considerable number of fertile individuals is needed to follow out the stages of spore-formation. In Dr. Coker's material of the variety *laxus*, there occur two or three plants with smaller pyriform-obovoid sporangia showing numerous chlorophyl-bodies, but apparently no spores; these we take to be immature aplanosporangia, but in the absence of direct observation of intervening stages the possibility that they represent sporangia of a different sort has suggested itself.

Coccocladus occidentalis laxus evidently has a closer affinity with **Coccocladus occidentalis Conquerantii,**† judging from Cramer's description, than with the typical *C. occidentalis*, but, we believe, differs too much from that to bear the same varietal name. The sporangia of *C. occidentalis Conquerantii*, according to Cramer, are at most only slightly ellipsoidal and occur only on branches of the first two orders. The number of spores to a sporangium and the size of the spores, characters which are in part relied upon by Cramer to separate his *Botryophora Conquerantii* from his *B. occidentalis*, appear in a considerable series of specimens of this genus now accessible to be extremely variable and unreliable for a specific separation. And Cramer's selection of a comparatively few-spored form for the typical *C. occidentalis* is hardly justified in view of Harvey's description of the spores as "innumerable," a characterization that is well substantiated by

* Livingston, B. E. On the Nature of the Stimulus which causes the Change of Form in Polymorphic Green Algae. Bot. Gaz. **30**: 289–317. *pl. 17, 18.* 1900.

——. The Rôle of Diffusion and Osmotic Pressure in Plants. Dec. Publ. Univ. Chicago, II. **8.** 1903.

† *Dasycladus Conquerantii* Crouan; Schramm & Mazé, Alg. Guadeloupe, 47 1865. Mazé & Schramm, Alg. Guadeloupe, 108. 1870–77.

Botryophora Conquerantii (Crouan) Cramer, Neue Denkschr. Schweiz. Naturf. Ges. **32**: 6. *pl. 4. f. 1.* 1890.

specimens of Harvey's collecting at Key West now in the herbarium of Columbia University, in which the number of spores to a sporangium is 200 or more. The peripheral arrangement of the spores about a central cavity, which Cramer emphasizes as a distinctive character of his *Botryophora Conquerantii*, and which that variety has in common with our variety *laxus*, seems to be more constant than number and size of spores and may be more significant. Specimens agreeing essentially with Cramer's description of *Botryophora Conquerantii* have been collected by the writer at Key West, Florida (*no. 1531*).

Neomeris Cokeri sp. nov.

Plants subcylindrical or clavate, 7–14 mm. long, 1.5–2.5 mm. thick, dark green in upper third or fifth, becoming grayish white below, apex rounded-obtuse or subtruncate, often exhibiting a delicate, translucent apiculum formed of the mantle-caps: * number of successive whorls of branches mostly 60–120; number of branches in a whorl 12–56: hairs of two forms in separate zones, those of one form consisting of a single, clavate, often curved or somewhat hooked cell rich in chlorophyl and having a maximum diameter about equal to that of the supporting cell, the apex acute, obtuse, or more often apiculate; those of the second form consisting of a somewhat similar though slightly narrower basal cell bearing at its apex one or two earlier caducous, more slender branches, these in turn each bearing 2–4 branches; unicellular hairs or basal cells of the multicellular persisting in the upper third or fifth of the plant, the surface after their fall appearing somewhat shaggy or minutely and irregularly punctate, a cortex scarcely developed: branches of the first order lightly calcified, scarcely coherent; branches of the second order more strongly calcified, irregularly and imperfectly coherent, subfusiform, often somewhat curved or gibbous, broadest (100–150 μ) a little above the middle, tapering to a conico-truncate apex 22–34 μ broad at the insertion of the hair: sporangia strongly calcified, free or coherent in short rows of 2–8, pyriform-obovoid, 180–206 μ long (decalcified and including stalk), 90–102 μ in maximum width, calcareous capsule 25–40 μ thick; spores obovoid, 140–156 μ × 82–94 μ. (PLATE 6, FIGURES 3–12.)

Opposite Current Town, Eleuthera, July 5, 1903. The material collected consists of about thirty individuals.

* "Kappentheile oder Mantelkappen" of Cramer, Neue Denkschr. Schweiz. Naturf. Ges. **32**: 12. 1890.

Neomeris Cokeri constitutes the third known species of the genus, all of which occur in the West Indian region. The principal diagnostic characters of the three species may be arranged as follows:

Hairs homogeneous; ends of the branches of the second order forming a cortex with distinct facets.

Plant reaching a height of 3.5 cm.; sporangia spherical or nearly so, strongly calcified but free. 1. *N. dumetosa.**

Plant reaching a height of 2 cm.; sporangia obovoid-oblong or pyriform-obovoid, about twice as long as broad (not including stalk), strongly coherent laterally by their calcareous capsules, so that the plant in the lower fertile parts appears transversely annulate. 2. *N. annulata.*†

Hairs dimorphous, the two forms in different zones; branches of the second order subfusiform, scarcely forming a cortex, surface of the plant after the fall of the hairs somewhat shaggy or minutely and irregularly punctate; sporangia free or coherent in short rows of 2-8. 3. *N. Cokeri.*

Neomeris annulata is not especially uncommon in the West Indian region. The writer has collected specimens in Bermuda, Key West, Florida (two stations) and Porto Rico (three stations). Of what appears to be the true *N. dumetosa*, we have seen only

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* NEOMERIS DUMETOSA Lamour. Hist. Polyp. 243. *pl. 7. f. 8.* 1816. Sonder, Alg. Trop. Austral. *pl. 5. f. 8–13.* 1871. J. Ag. Till. Alg. Syst. 5: 147–151. *pl. 2. f. 4–7.* 1887. Cramer, Neue Denkschr. Schweiz. Naturf. Ges. **30**: — (10, 38) *pl. 2. f. 13–15; pl. 3. f. 3.* 1887. Cramer, *op. cit.* **32**: 19. *pl. 1. f. 13.; pl. 2. f. 7, 8.* 1890. De-Toni, Syll. Alg. **1**: 413. 1889. Solms, Ann. Jard. Bot. Buitenzorg, **11**: 70. *pl. 8b. f. 11.* 1893.

† NEOMERIS ANNULATA Dickie, Jour. Linn. Soc. **14**: 198. 1874. De-Toni, Syll. Alg. **1**: 414. 1889. Solms, Ann. Jard. Bot. Buitenzorg, **11**: 61–71. *pl. 8. f. 1, 3, 4, 7, 8, 12, 13,* 17. 1893.

Neomeris Kelleri Cramer, Neue Denkschr. Schweiz. Naturf. Ges. **30**: —(3). *pl. 1; pl. 2. f. 1–12; pl. 3. f. 1, 2.* 1887. Cramer, *op. cit.* **32**: 9. *pl. 1. f. 1–12; pl. 2. f. 1–6; pl. 4. f. 15–24.* 1890. De-Toni, Syll. Alg. **1**: 413. 1889.

Neomeris Eruca Farlow; Cramer, Neue Denkschr. Schweiz. Naturf. Ges. **32**: 9, 18, 19. 1890.

The names *Dactylopora Eruca*, *D. digitata*, and *D. Annulus* of Parker and Jones (Ann. and Mag. Nat. Hist. III. **5**: 473, 474. 1860), quoted by Cramer in the synonymy of his *Neomeris Kelleri*, were originally applied simply to calcified spore-masses and fragments of a *Neomeris* from the "East Indian and other tropical seas," and cannot, in our opinion — especially since the discovery of *Neomeris Cokeri* with its peculiar hairs — be safely identified with any definite species, though as between *Neomeris dumetosa* and *N. annulata*, *Dactylopora Eruca* and *D. Annulus* clearly belong with the latter type. The name *Neomeris Eruca* Farlow apparently was first published by Hauck in Engler's Bot. Jahrb. (**9**: 469. 1888) but this, so far as the technicalities of publication are concerned, rests on the *Dactylopora Eruca* synonym alone, and is therefore, we believe, of uncertain application.

one specimen — the one from Hawaii distributed as *Neomeris dumetosa* by Miss Tilden in American Algae, *no. 445*. *No. 668* of the Phycotheca Boreali-Americana (St. Thomas, *Börgesen*, Jan. 1896) distributed as *Neomeris dumetosa* has, in the two copies seen, the characters of *N. annulata*. The original description of *Neomeris dumetosa*, as given by Lamouroux, with its "bulles conoïdes ou pédiculées, se touchant entre elles tant elles sont nombreuses, mais sans être coalescentes," combined with Cramer's redescription of the original material (collected in the Antilles by Richard) can leave little doubt as to what *Neomeris dumetosa* really is. The type of *Neomeris annulata* came from Mauritius, where it was collected by Colonel Nicolas Pike. The species is not represented in Colonel Pike's herbarium, now in the possession of the New York Botanical Garden, but Count Solms has seen * the original material preserved in the British Museum and his figures drawn from Mauritius specimens would apply very well to the specimens from Bermuda, Porto Rico, and St. Thomas, alluded to above. Solms-Laubach refers Porto Rican material to this species, using the name *Neomeris annulata*, and Cramer refers to the same both Porto Rican and Bermudian specimens, preferring, however, the name *Neomeris Kelleri*.

CYSTOSEIRA MYRICA (Gmel.) Ag.

Gregory Town, Eleuthera.

LIAGORA ANNULATA J. Ag.

Gregory Town, Eleuthera.

Somewhat resembling *Liagora valida* in habit, but clearly distinct — firmer, beautifully annulate from near the base to the partially calcified apices; the apices are rounded-obtuse in fluid-preserved material, but often become attenuate-acuminate on drying. The annulations appear to be due to unequal calcification in well-defined alternating zones.

NEW YORK BOTANICAL GARDEN.

* Ann. Jard. Bot. Buitenzorg, 11: 61. 1893.

Explanation of plate 6

Figs. 1 and 2. *Coccocladus occidentalis laxus;* 3–12, *Neomeris Cokeri.*

1. One of the whorled branches of *Coccocladus occidentalis laxus*, with sporangia, × 12.

2. A single sporangium, × 40.

3. *Neomeris Cokeri*, natural size.

4. A single plant, × 8. At the apex, in this individual, is a zone of multicellular hairs, surrounding and concealing the apiculum formed of the mantle-caps; below, are the unicellular hairs, and farther downward, the lime-coated sporangia, isolated, or coherent in short rows.

5. Apical portion of another plant, × 12. The hairs in the apical region are here of the unicellular kind and the apiculum formed of the mantle-caps is conspicuous; below is a zone of multicellular hairs.

6. A fertile primary branch, with branches of the second order, each, in this case, bearing a unicellular hair, × 40. (Decalcified.)

7. A similar fertile primary branch, × 40. (Decalcified.)

8. A fertile primary branch, with branches of the second order, each, in this case, bearing a multicellular hair, × 40. (Decalcified.)

9. The conditions in this figure are similar to those represented in Fig. 8, except that only the basal cells of the multicellular hairs now persist. Scars remain indicating the places of insertion of the hair-segments which have fallen. In this stage the two forms of hairs sometimes resemble each other, but the persisting bases of the multicellular may be recognized by the presence of these scars, which are always entirely wanting on hairs of the unicellular kind.

10. Part of a primary whorl, with sporangia and branches of the second order, × 40, with calcareous coating.

11. A single primary branch, with sporangium and branches of second order, with calcareous coating, × 37.

12. A mature spore, within the sporangium, decalcified, × 53.

The drawings have been made by the writer, with some assistance from Mr. A. Mariolle in preparing them for reproduction.

INDEX TO AMERICAN BOTANICAL LITERATURE

(1901–1903)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omission their kindness will be appreciated.

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